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Indian Standard

GUIDE FOR REPAIR OF PRINTED WIRING BOARDS AND ASSEMBLIES

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

GUIDE FOR REPAIR OF PRINTED WIRING BOARDS AND ASSEMBLIES

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Indian Standard

GUIDE FOR REPAIR OF PRINTED WIRING BOARDS AND ASSEMBLIES

0. FOREWORD

0.1 This Indian Standard was adopted by Indian Standards Institution on 14 December 1984 after the draft finalized by the Printed Circuits Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard recommends good principles and practices which should be applied to printed wiring boards which need to be repaired in the normal course of component assembly and test prior to release to the user. In certain instances the techniques described would also be suitable for use on repairs carried out in other circumstances.

0.3 The repair of printed wiring boards covered in this guide fall into one or other of the following categories:

a) Corrective touch-up carried out as part of the normal production and inspection procedures and used where minor defects occur,

b) Corrective action on more defects that in themselves would be cause for rejection,

c) Modifications requested by the customer, and

d) Rectification of prescribed defects.

0.4 All the techniques described are applicable to printed wiring boards for which the base material is metal clad/epoxy glass, epoxy paper, or phenolic paper laminates.

0.5 Throughout this standard, the word 'REPAIR' is used also to cover MODIFICATIONS, or RECTIFICATIONS.

1. SCOPE

1.1 This standard provides guidance for repair, including modifications and rectifications, of printed wiring boards.

2. TERMINOLOGY

2.0 In addition to the terms and definitions as given in IS: 1885 (Part 6)-1978*, the following are used in this standard.

*Electrotechnical vocabulary: Part 6 Printed circuits (*first revision*).

2.1 Rework — Rectification of defects occurring during manufacture of the printed board. Rework is carried out by the board manufacturer before delivering the printed boards to the user.

2.2 Repair, Printed Board — Rectification of defects occuring after acceptance of the printed board by the user, that is during assembly and use. Repair is normally carried out by the user.

2.3 Repair, Printed Board Assembly — Rectification of defects occuring after assembly, that is, during testing and use, mainly replacement of defect components. Repair is normally carried out by the user.

2.4 Modification — Change to the printed board or printed board assembly including deletion and addition of components and conductors.

3. GENERAL

3.0 For unassembled printed wiring boards the techniques described in this standard may be used subject to the requirements of the relevant procurement specification. It would be remembered that the defects on the unassembled printed wiring board fall into two categories:

a) Those defects that may be repaired without customer notification; and

b) Those defects that require customer notification and approval before reworking.

3.0.1 It is an essential requirement in both groups that the methods of repair are limited to those not affected by soldering temperatures so that boards may be processed in the normal way. Typical examples of such methods are those involving welding, conductive compounds and plating. Some of the techniques involve considerable amount of operator time, and due regard should be given to their cost-effectiveness.

3.1 With the exception of the techniques stated for the repair of short or near short circuits on the surface laminate (*see* **14**) additional work, on printed wiring boards, of any type, should only be performed with the full agreement of the customer.

3.2 With the exception of the techniques stated for multilayer repair (*see* **15**) all of the repair methods have proved to be practical in operation and acceptable in service. Multilayer repairs require a very high degree of skill and specialized equipment and should therefore be a matter of negotiation with the customer and be clearly defined in any repair contract or agreement.

3.3 It is recommended that the number of repairs carried out to an assembled printed wiring board should not exceed 2. In the case of high value

printed wiring boards exceptions to the norm should be treated on an individual basis.

NOTE — The listing of techniques (*see* 5) should not be considered exclusive.

3.4 In many cases, alternative methods are quoted, and the choice may be influenced by the assembly method.

3.5 The repair should be carried out by trained and competent operators who have been nominated for this work and equipped with all the appropriate facilities. A detailed Operator's Procedure/Capability Manual, based upon the techniques in this standard, may be prepared for the type of repair to be carried out.

3.6 The techniques listed are, in general, not suitable for printed wiring boards with conductor widths/spacings of less than 0·25 mm. The conductor pattern may be critical in some assemblies, and this should be taken into account when assessing and agreeing the feasibility of the proposed repair.

3.7 A clear indication should be obtained from the customer, in a repair contract or agreement, of the extent of repairs that he is prepared to accept. Any method considered to be inapplicable shall be clearly stated. It should be borne in mind that the customer may not accept any repairs.

NOTE — Repair should be permitted only when the cause of failure is understood, as a fault could be indicative of latent weaknesses elsewhere in the board(s), or in the production method.

3.8 If it is intended to use a material not described in this guide the agreement of the customer should be obtained.

3.9 All repaired printed wiring boards should be clearly identified with a distinctive indelible marking. The marking should be non-conductive.

NOTE — Component changest hat cause no damage to the basic board are not deemed as repairs.

3.10 Repairs should not reduce the conductor current carrying capability and conductor spacings below the original allowed tolerance.

3.11 Where an original surface coating is removed, either completely or locally during the application of a method from this standard, it should be restored on completion of the work. In the event of the original coating being unobtainable or its use being impracticable, a substitute acceptable to the customer should be employed.

3.12 On completion of the work, the printed wiring board(s) should be visually inspected at a suitable magnification. Other tests that may be required in order to meet the customer's specification should also be applied.

3.13 Assembled printed wiring boards offered for repair may contain electrostatic sensitive devices. Electorstatic charges occurring between the leads of the device can cause total component failure or degrade reliability.

3.13.1 Printed wiring boards containing electrostatic sensitive components will generally be identified by a warning label on part of the board and by the use of special packing materials.

3.13.2 When carrying out component charges/repairs to boards containing electrostatic sensitive devices it is essential that protection against static electricity be taken. Guidance may be taken from IS : 10087-1981*.

4. SAFETY

4.1 It should be noted that some of the techniques used to effect repairs could be considered as hazards if used by untrained personnel, furthermore, some chemicals used may be harmful to the skin and eyes, or dangerous if taken orally. Manufacturers' instructions regarding the use of potentially hazardous material should be strictly observed, and at all times, strict hygiene must be observed and full use made of protective measures such as barrier creams, gloves, eye protection etc. Personal hygiene on completion of such operations is essential.

NOTE — The use of barrier creams can cause contamination problems on board surfaces that are subsequently to be bonded or soldered.

5. REPAIR METHODS

5.1 Techniques for the repair of printed boards are listed under the following headings:

a) Component removal and replacement (*see* **6**),
b) Defective conductors—Single and double-sided boards (*see* **7**),
c) Lifted conductors (*see* **8**),
d) Lifted and defective lands (*see* **9**),
e) Eyelets and tubular pin defects (*see* **10**),
f) Plated through hole defects—Double-sided boards (*see* **11**),
g) Base board material defects (*see* **12**),
h) Inclusions (*see* **13**),
j) Short or near short circuits on the surface laminate (*see* **14**),
k) Repair of inner layers of multilayer printed wiring boards (*see* **15**),
m) Repair of printed edge connectors (*see* **16**),
n) Protective coating removed (*see* **17**),
p) Modification of assembled printed wiring boards (*see* **18**), and
q) Guide to suitable tools and materials (*see* **19**).

*Code of practice for handling of electrostatic sensitive devices.

6. COMPONENT REMOVAL AND REPLACEMENT

6.1 Where components are to be removed from printed boards to allow access or to be replaced because they are defective they need to be removed with great care to prevent damage to the printed board or other components. This could be caused by excessive heat, improper tool use, rough handling, or static electricity. Protective printed wiring board coating may also need to be removed (*see* **17**).

WARNING — Printed boards offered for repair may contain electrostatic sensitive devices. Normal handling may completely destroy these devices (*see* **3.13**).

6.2 Removal of Components with Leads Accessible from the Component Side — For typical components *see* Fig. 1 and 2.

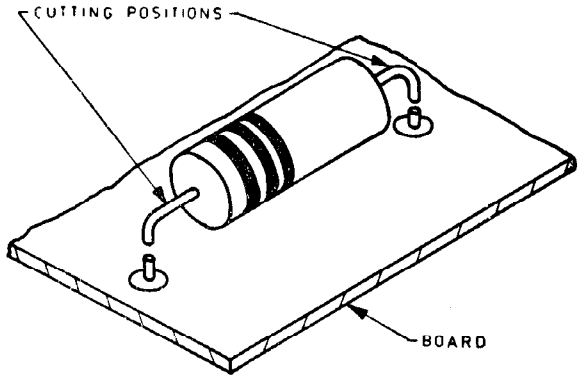


FIG. 1 COMPONENTS OF THE RESISTOR, CAPACITOR TYPE WITH TWO AXIAL LEAD OUT WIRES

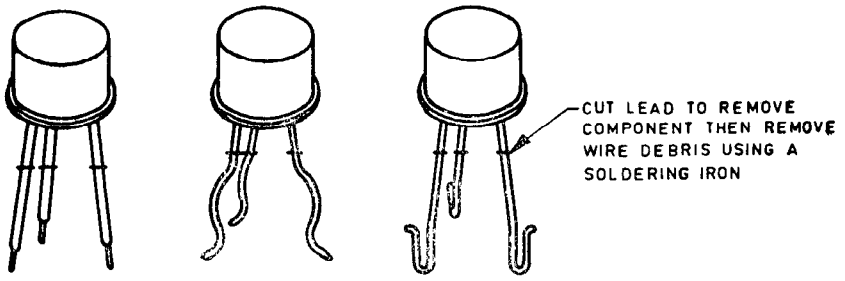


FIG. 2 COMPONENTS WITH MULTI-LEAD OUT WIRES OF THE OD18 AND OD19 TYPE TRANSISTORS

6.2.1 The recommended removal method for components such as resistors and capacitors with two axial leads transistors of the OD18 and OD19 type where the lead out wires are accessible from the component side of the board, is to cut the component wire. (*see* Fig. 1 and 2).

6.2.2 Apply a temperature controlled soldering iron to the soldered joint and quickly remove the remaining wire and solder. If any solder remains in the hole it should be removed using a desoldering tool.

Before fitting a new component the land/hole should be examined for signs of damage. For the repair of damaged base board material refer to **12.** The new component should be fitted in the usual way and any removed board coatings should be repaired.

6.3 Removal of components of the OD18 and OD19 transistor type where lead outs are not accessible from the component side or where the component must be salvaged (for typical components *see* Fig. 3).

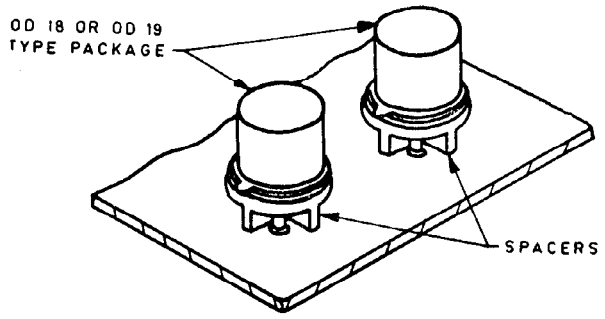


FIG. 3 COMPONENTS WITH LEAD OUT WIRES THE LEADS ARE INACCESSIBLE FROM THE COMPONENT SIDE

6.3.1 Using a desoldering tool, preferably of the vacuum pump type, remove all the solder from the lead areas. If the component lead outs are bent down use a soldering iron to remelt the solder around one lead at a time and bend the lead vertical to the printed wiring board using a dentist's probe while the solder is still liquid. The component should then be free to separate from the board if not, repeat the above. Before fitting a new component, the land/hole should be examined for signs of damage and the holes free from solder. For repair of damaged base board refer to **12.** Any removed board coatings should be redone.

6.4 Removal of the Dual-in-Line Component Mounted Through the Board — For a typical component *see* Fig. 4.

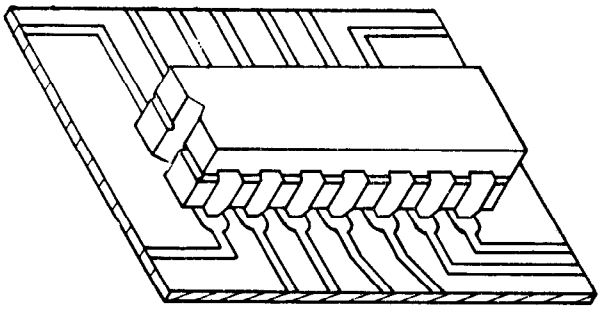


FIG. 4 DUAL-IN-LINE PACKAGES — MOUNTED THROUGH THE BOARD

6.4.1 The removal of components of this type requires a high degree of skill.

It is recommended that removals of this type are only attempted using a desoldering system with a suitable vacuum pump. Using a desoldering system, remove the solder from all the components.

The component may now be free to remove from the board, if not repeat the operation, ensuring that the solder is removed from the offending holes.

6.4.2 Where the component has bent down leads, using a soldering iron remelt the solder around the lead and straighten with a dentist's probe or scalpel while the solder is still liquid, and proceed as above. Before fitting a new component in the normal way, inspect the lands and holes for damage. Holes should also be free from solder. On the repair of damage refer to the appropriate clause. Any removed printed wiring board coatings should be redone.

6.5 Removal of Surface Mounted Dual-in-line Components — For a typical component *see* Fig 5.

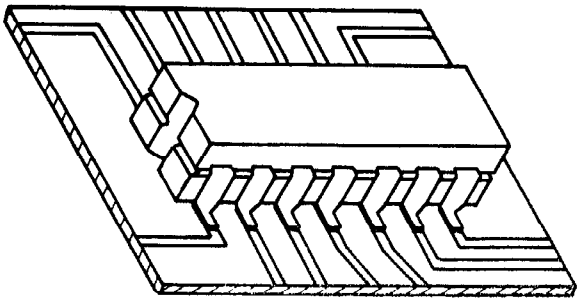


FIG. 5 DUAL-IN-LINE PACKAGS — SURFACE MOUNTED

6.5.1 This method assumes that the components are soldered and not welded and that the component body is not affixed to the board with adhesive. Original component assembly techniques may include the fitting of surface mounted components using built reflow machines that reflow all terminations in one operation. These methods of component removal are not recommended for isolated repairs, they require careful 'setting up' and usually present problems of accessibility on a fully assembled board. They may however, be used if preferred. Component removal and replacement should, if required, from part of their process manual.

6.5.2 To remove surface mounted dual-in-line components use a soldering iron to melt the solder from around each lead in turn and lift from the board using a special probe. Care should be taken to apply the soldering iron for sufficient time only to enable the lead to be freed. With a soldering tool, remove any excess solder from the lands. Examine lands for damage, if damaged repair as defined in the appropriate clause. The replacement components lead should be tinned.

6.5.2.1 Position the component and resolder each lead with only sufficient heat to effect a successful joint. Use a flat probe to hold lead in position until the reflowed solder has solidified. Any removed coatings should be restored.

7. DEFECTIVE CONDUCTORS — SINGLE AND DOUBLE-SIDED BOARDS

7.1 Defective conductors are conductors that show evidence of:

a) a complete break, that is, no electrical continuity;

b) scratches, nicks or pinholes, which reduce the effective cross-sectional area of the conductor beyond the specified design tolerance as illustrated in Fig. 6.

7.1.2 Where the surface scratch is capable of being filled with solder, the solder shall flow over the conductor surface for not less than 3 mm either side of the scratch. These are not considered to be repairs. *Deep Scratches* or surface scratches that are not capable of being filled with solder should be repaired to a method selected from Table 1.

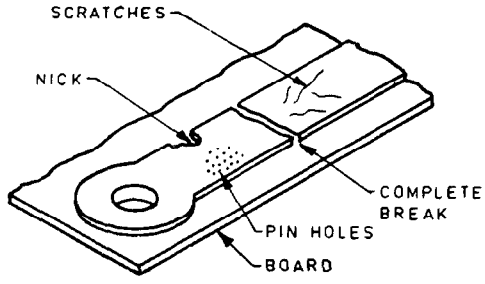
NOTE 1 — Where solder resist etc has to be removed, this should be achieved by the careful use of a sharp instrument such as a scalpel, fine abrasive paper, glass fibre brush, suitable solvent or similar devices.

NOTE 2 — It should be noted that glass fibre debris may impair solderability.

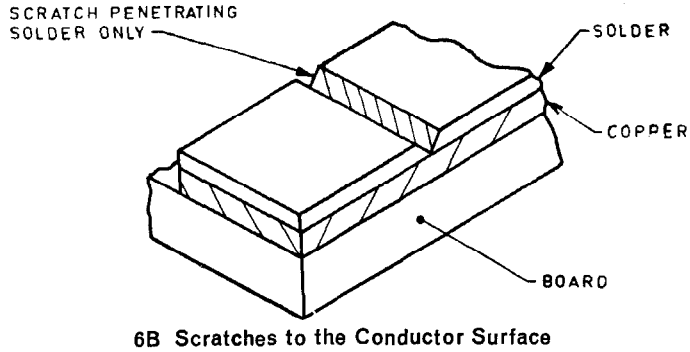
7.2 Applicability of Techniques for the Repair of Defective Conductors — Table 1 lists the suggested constraints on the distance to be bridged when reworking defective conductors. Where soldering is used, a good fillet should be produced which is bright and smooth in appearance.

When the work is complete, the surface protection should be restored either by the original method or compatible coating.

Where the defective conductor needs to be removed, removal should be achieved by a scalpel or similar instrument.



6A Defective Conductor



6B Scratches to the Conductor Surface

FIG. 6 SURFACE DEFECTS TO CONDUCTORS

7.3 Copper Foil Connections -- This method is preferred for the repari of scratches, pinholes and breaks, but where the track widths are less than 0·5 mm the foil strips become difficult to handle and the repair may have to be carried out with a suitable thickness of tinned copper wire, as described in **7.4.**

7.4 A piece of pre-tinned copper foil of similar width should be soldered on to the conductor with a minimum overlap of 3 mm on either side of the defect. The thickness of the foil should be between 0·035 mm and 0·070 mm for conductors of 0·035 mm thickness and proportionately thinner or thicker for other conductors. The part of the foil which bridges the defect in the conductor should be bonded to the exposed part of the board,

irrespective of the size of the conductor. This method is illustrated in Fig. 7.

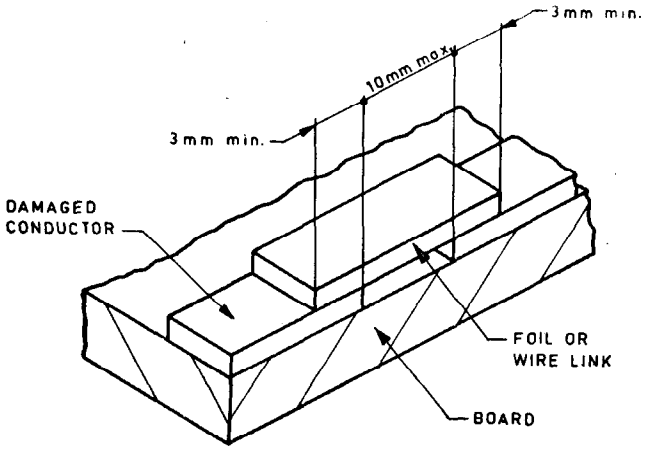


FIG. 7 COPPER FOIL CONNECTIONS

7.5 Tinned Copper Wire Connections — Where the distance to be bridged is less than 20 mm, the break should be bridged by means of bare tinned copper wire soldered to the tracks.

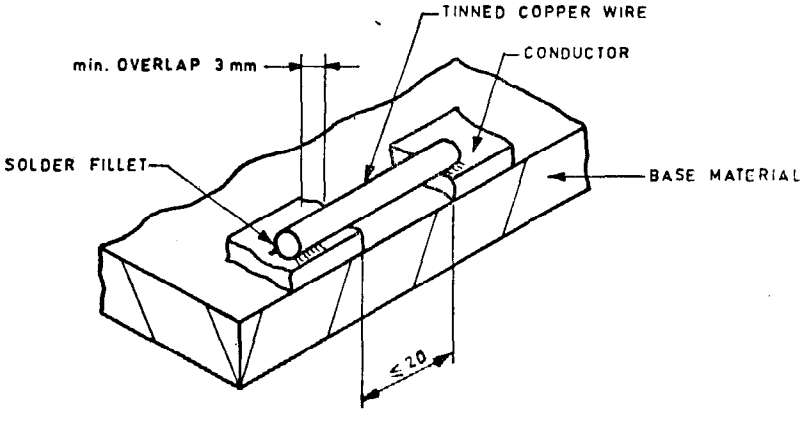


FIG. 8 TINNED COPPER WIRE CONNECTIONS

7.5.1 A length of bare tinned copper wire should be soldered to the conductor on either side of the defect, with a minimum overlapping joint size of 3 mm. The appropriate wire diameter is determined by the conductor width. The bridging wire should be centered on and in line with the original conductor. The metod is illustrated in Fig. 8.

NOTE — The wire may be bonded to the printed wiring board to provide additional strength and to fill the gap between the wire and the board.

TABLE 1 APPLICABILITY OF TECHNIQUES FOR REPAIR OF DEFECTIVE CONDUCTORS

(*Clauses* 7.1.2 *and* 7.2)

TECHNIQUE	DISTANCE TO BE BRIDGED (in mm)				COMMENT
	0 to 10	10 to 20	20 to 40	Over 40	
(1)	(2)	(3)	(4)	(5)	(6)
Soldered copper foil	Suitable	Unsuitable	Unsuitable	Unsuitable	Not recommended prior to mass soldering.
Tinned copper wire	Suitable	Suitable	Unsuitable	Unsuitable	Not recommended prior to mass soldering.
Insulated wire	Suitable	Suitable	Suitable	Suitable	Not recommended prior to mass soldering.
Insulated wire and holes	Suitable	Suitable	Suitable	Suitable	Alternative to above (insulated wire) not recommended prior to mass soldering.
Welded tape or foil	Suitable	Suitable	Unsuitable*	Unsuitable*	*Unsuitable unless supported by tack bonding with epoxy adhesive over the entire length of type/foil.
Welded tape or foil with insulation	Suitable	Suitable	Unsuitable*	Unsuitable*	*Unsuitable unless supported by tack bonding with epoxy adhesive along the entire length of the tape/foil. Not suitable prior to mass soldering.

7.6 Insulated Wire Connections — Where the distance to be bridged exceeds 20 mm the repair should be carried out as under **7.5** but insulated or sleeved wire should be used. This method is illustrated in Fig. 9. It is recommended that the insulated portion of the wire be secured to the board with a suitable adhesive.

NOTE — Insulated wire method may be used for distances less than 20 mm.

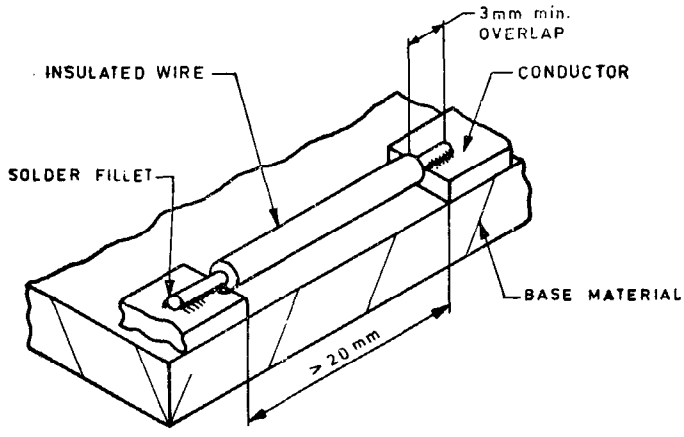


FIG. 9 INSULATED WIRE CONNECTIONS

7.7 Insulated Wire and Using Drilled Hole Connections — This repair method is similar to that described in **7.5** except that the wires should be run on the opposite side of the board via holes drilled in the laminate.

The wire should be secured at appropriate intervals along its length using an epoxy adhesive.

NOTE — Extreme care should be exercised when selecting the hole positions on double sided boards to prevent damage to possible underside tracks. This technique is not suitable for track widths of less than 1·5 mm.

7.7.1 The ends of a length of insulated wire should be fed through 0·8 mm holes drilled on either side of the break in the conductor at a minimum distance of 0·5 mm from the broken ends. The bare ends of the wire should then be soldered to the conductor with a minimum overlap of 3 mm. This method is illustrated in Fig. 10.

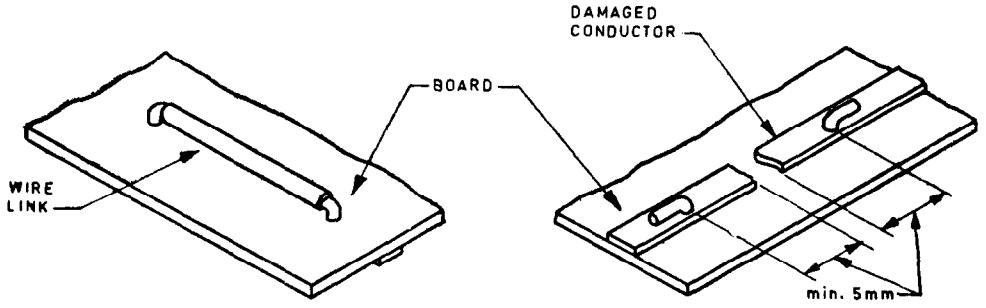


FIG. 10 INSULATED WIRE USING DRILLED HOLE CONNECTIONS

7.8 Repair Using Parallel Gap Welding Techniques

7.8.1 *Description of Process* — The parallel gap welding process is a series resistance welding method with precise controls of the welding machine variables. The welding current is passed form one electrode, through the region of the joint, and back through the adjacent electrode. Both of the closely spaced electrodes bear independently on the conductor material. The printed wiring board is supported against the force of the electrode by a platen.

7.8.2 *Process Requirements* — The conductor under repair should be either weldable or capable of being converted to a weldable condition. The repair medium is normally nickel alloy tape or suitable equivalent of width 0·254 mm to 0·330 mm and thickness 0·076 mm to 0·127 mm with a nickle flash followed by gold flash.

7.8.3 *Straight Conductor Repair* — The repair should be carried out as shown in Fig. 11. The tape should be approximately parallel to, and centered upon, the conductor.

NOTE — For bridging distances in excess of 20 mm, the tape may be insulated and secured to the board with a suitable adhesive.

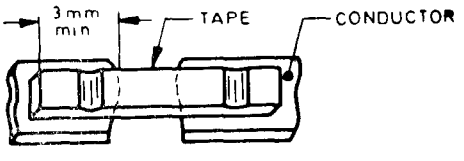
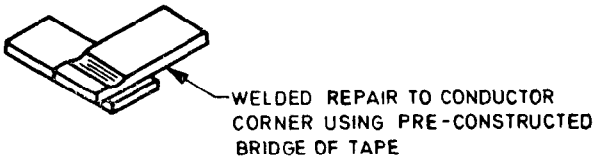
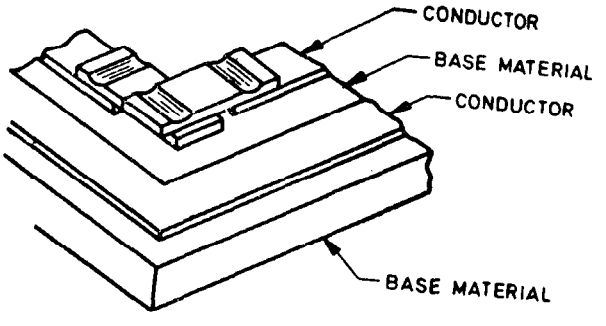


FIG. 11 PARALLEL GAP WELDING — STRAIGHT CONDUCTOR REPAIR

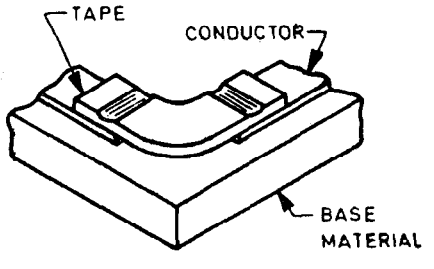
7.8.4 *Corner Repair* — Defective conductor corners may be 'reworked' as shown in Fig. 12.



12 A



12 B



12 C

FIG. 12 PARALLEL GAP WELDING — CORNER REPAIRS

8. LIFTED CONDUCTORS

8.1 A lifted conductor is detached from the base laminate but not broken (*see* Fig. 13).

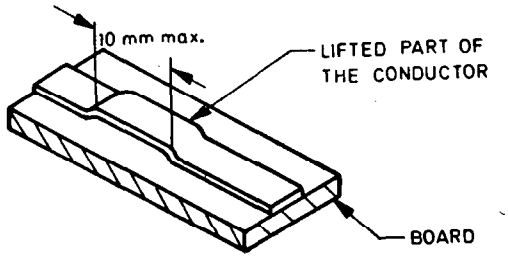


FIG. 13 LIFTED CONDUCTORS

8.1.1 The repair permitted by the following methods is limited to the lifted portions of conductors which are not greater than half the length of the conductor measured between the two terminal lands, and does not exceed 12 mm in length. Where the lifted portion exceeds the above dimensional limits the track should be considered to be broken and repaired accordingly.

8.1.2 The bond between the conductor and the laminate may be restored using the following procedure:

a) If any coating is present, it should be removed from the affected area. The underside of the lifted conductor and the area of board directly beneath the lifted conductor should be cleaned with a solvent cleaner applied with a fine hair brush, removing all contaminates from both surfaces, and then allowed to dry;

b) An approved adhesive should be carefully distributed under the entire length of the lifted conductor;

c) The conductor should then be firmly pressed into contact with the printed wiring board;

d) All excess adhesive should be removed;

e) The adhesive should be allowed to cure; and

f) If the original protective coating has been removed, it should then be restored.

9. LIFTED AND DEFECTIVE LANDS

9.1 Defective Land — A defective land is any land which has been damaged.

NOTE — These procedures should not be applied to plated-through holes.

9.1.1 *Overlaid Lands* — Where the adhesion of the land is satisfactory and the area has been reduced by not more than 25 percent, the land

may be overlaid with a second land which may be obtained from another board or repair foil. Where the damage is in excess of 25 percent the land shall be considered to be missing and repaired accordingly. This method is illustrated in Fig. 14.

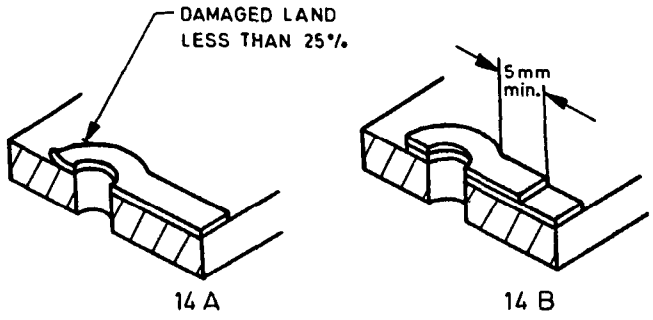


FIG. 14 OVERLAID LANDS

9.1.1.1 The underside of the land should be cleaned with fine abrasive paper, and after removal of all debris, 'tinned' with solder using a small iron. A non-solderable pin inserted in the hole should be used to align the lands. The land should be soldered over the existing land and conductor, so that at least 5 mm of conductor is overlapped.

9.1.2 *Replacement of Damaged Lands* — The repair may be affected by bonding a replacement land to the laminate by means of suitable adhesive (*see* Fig. 15) after having carefully cut away the remains of the damaged land.

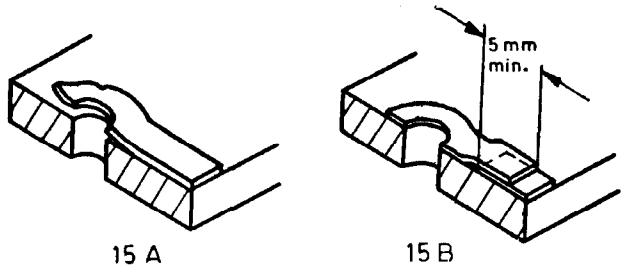


FIG. 15 REPLACEMENT BONDED LANDS

9.1.2.1 The replacement land should have sufficient length of conductor attached to it to enable an overlap at least 5 mm to be soldered to the existing conductor. The distance between the end of the existing

conductor and new land should not be greater than 5·0 mm. The following procedure should then be followed:

a) First clean and tin the affected conductor on the board and only the overlapping portion of the replacement conductor. The replacement land should then be positioned over the existing hole, using a non-solderable pin in order to maintain alignment of holes. Solder the tail of the replacement land to the conductor, ensuring that an overlap of at least 5 mm is maintained. Do not tin the underside of the replacement land, since adhesion of the adhesive to tinned surfaces is not as effective as that to copper.

b) The underside of the replacement/conductor land and the topside of the board area to be repaired should be completely freed of flux and dirt by cleaning with a solvent cleaner applied with a fine hair brush. These areas should be allowed to dry before proceeding with the next operation.

c) The replacement land/conductor should be lifted just enough so that a thin smear of adhesive can be applied to the underside of the land, and also to the top of the board. Under no circumstances must adhesive be allowed on the upper surface of the replacement land.

d) The land should then be pressed down with a blunt instrument and any excess adhesive removed.

e) The adhesive allowed to cure.

f) Where an original coating has been removed, it should be restored.

9.2 Lifted Lands — These techniques shall not be applied to through-plated hole lands.

9.2.1 When part of the conductor lifts as well as the land (Fig. 16), the loose area may be removed by the use of a sharp instrument, and the repair may be carried out as given in **9.1.2** or by the following method.

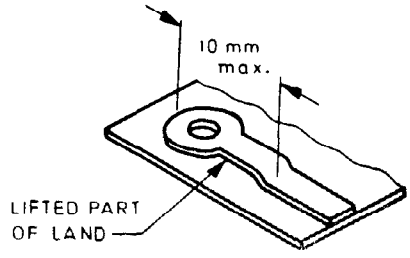


FIG. 16 LIFTED LANDS AND CONDUCTOR

9.2.2 The bond between the lifted land and the laminate may be restored by the use of a suitable adhesive. The following procedure should be used:

a) The land should be raised carefully and the underside of the land and topside of the board should be cleaned by a solvent cleaner applied with a fine brush and then allowed to dry.

b) A suitable adhesive should then be applied to the underside of the land and the topside of the board with a clean spatula.

c) The land should then be pressed down.

d) Any surplus adhesive should be removed.

e) The adhesive allowed to cure.

f) Where the original coating has been removed it should be restored.

9.3 Missing Lands — This repair method is not suitable for the repair of through-plated holes.

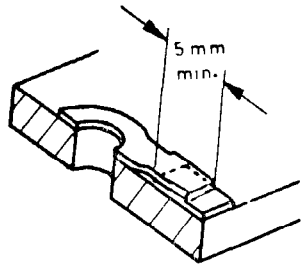


FIG. 17 MISSING LANDS

9.3.1 The repair may be affected by bonding a replacement land to the laminate by means of a suitable adhesive (*see* Fig 17).

The replacement land should have sufficient length of conductor to enable an overlap of at least 5 mm to be soldered to the existing conductor.

NOTE — This method is not suitable for the repair of plated through holes.

9.3.2 The following procedure should then be followed :

a) First clean and tin the affected conductor on the board and only the overlapping portion of the replacement conductor. The replacement land should then be positioned over the existing hole, using a non-solderable pin in order to maintain alignment of holes. Solder the tail of the replacement land to the conductor, ensuring that an overlap of at least 5 mm is maintained. Do not

tin the underside of the replacement land, since adhesion of the adhesive to tinned surface is not as effective as that to copper.

b) The underside of the replacement/conductor land, and the topside of the borad area to be repaired should be completely freed of flux and dirt by cleaning with a solvent applied with a fine hair brush. These areas should be allowed to dry before proceeding with the next operation.

c) The replacement land/conductor should be lifted just enough so that a thin smear of adhesive can be applied to the underside of the land, and also to the top of the board. Under no circumstances must adhesive be allowed on the upper surface of the replacement land.

d) The land should then be pressed down with a blunt instrument and any excess adhesive removed.

e) The adhesive should be allowed to cure.

f) Where an original coating has been removed, it should be restored.

10. EYELETS AND TUBULAR PINS DEFECTS (*see* Fig. 18)

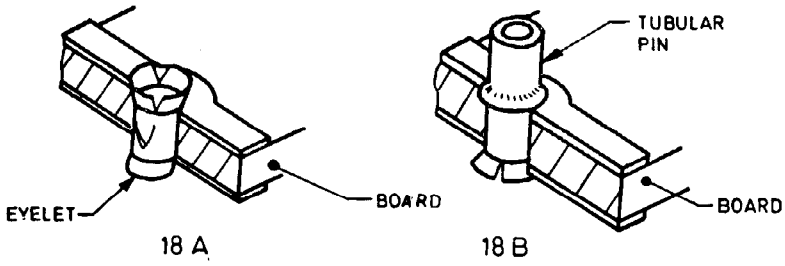


FIG. 18 EYELET DEFECTS, TUBULAR PINS AND SIMILAR ITEMS

10.1 Eyelets Damaged, Improperly Inserted, Defective or Producing an Unsatisfactory Through Connection

10.1.1 An eyelet, which otherwise appears satisfactory, but which constitutes an unsatisfactory through connection, may be resoldered after thoroughly cleaning around the flanges on both sides of the printed wiring board.

After resoldering, all residues should be removed with a suitable solvent cleaner and a fine hair brush. Where an original coating has been removed, it should be restored.

10.1.2 An eyelet which is incomplete, too small, or has a deformed barrel, may be carefully drilled out and a new eyelet inserted using an approved eyelet insertion tool.

10.1.3 An eyelet which is solely used as a through connection, and is defective, should be carefully drilled out and a new eyelet fitted using an approved eyelet insertion tool.

11. PLATED THROUGH HOLE DEFECTS — DOUBLE-SIDED BOARDS (*see* Fig. 19)

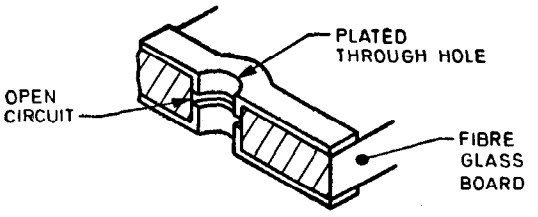


FIG. 19 OPEN CIRCUIT PLATED THROUGH HOLE

11.0 Methods described in **11.1** and **11.3** can be used only where a component lead is *NOT* required to be soldered into the plated through hole. Where the hole is used for a component lead the hole should be drilled out and an eyelet fitted as **11.2**.

11.1 Wire Link Method — A length of tinned copper wire should be inserted through the hole. The ends of the wires should be clenched such that they extend for 1 mm to 3 mm along the lands' conductor on each side of the printed wiring board (*see* Fig. 20).

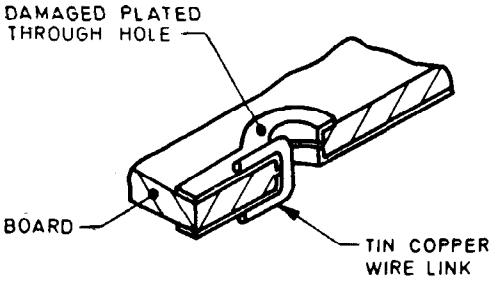


FIG. 20. DEFECTIVE PLATED THROUGH HOLE — WIRE LINK METHOD

11.2 Eyelet Method — Electrical contact between sides may be restored by inserting a suitable eyelet.

The hole may be drilled out to take the eyelet and the eyelet should be soldered to the lands on either side of the board. Commercially available eyelets of the solder fused type may be used (*see* Fig. 21).

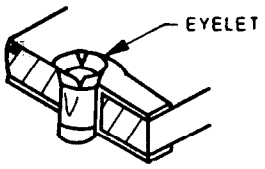


FIG. 21 DEFECTIVE PLATED THROUGH HOLE — EYELET METHOD

11.3 Repairs to Plated Through Holes Using Parallel Gap Welding Techniques

a) Description of the process (*see* **7.8.1**),

b) Process requirements (*see* **7.8.2**), and

c) *Through connection repair* — The repair should be carried out by the parallel gap welding method as shown in Fig. 22 and 23. The tape should overlap the conductor by a minimum of 3 mm and sharp corners on bends in the tape should be avoided.

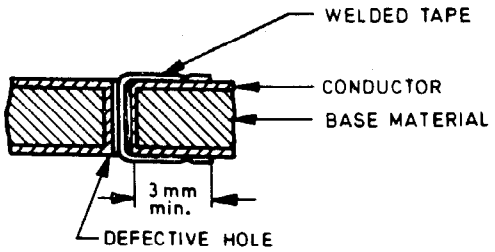


FIG. 22 DEFECTIVE PLATED THROUGH HOLES — PARALLEL GAP WELDING METHOD 1

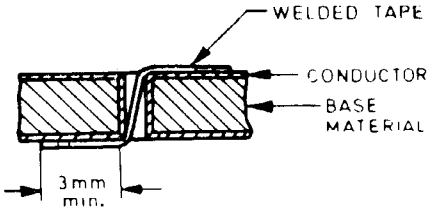


FIG. 23 DEFECTIVE PLATED THROUGH HOLES — PARALLEL GAP WELDING METHOD 2
(Suitable for via holes only).

12. BASE BOARD MATERIAL DEFECTS (For example, defects in epoxy-glass laminate).

12.0 Damaged Base Board Materials — It is the intention of this method to give guidance for the possible repair of minor damage to high value printed wiring boards (*see* Fig. 24).

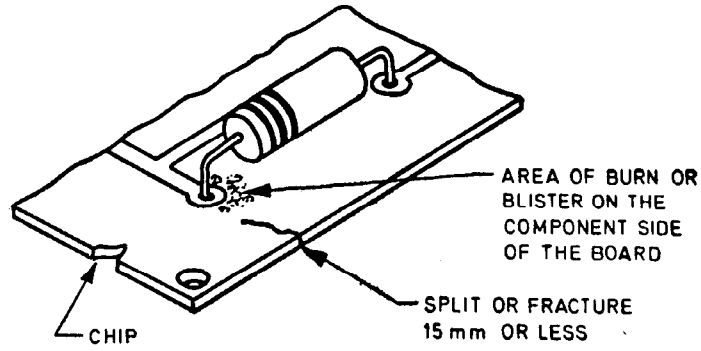


FIG. 24 DAMAGED BASE BOARD MATERIALS

Damage in this case is considered to be blisters, burns, splits, chips and fractures to the base laminate.

a) Damage of *minor nature* to high value boards in which the serviceability and reliability of the boards is unimpaired, may be repaired as stated below. For repairs to printed edge connectors *see* **16.**

b) Any damage to low value boards or damage greater than that stated in (a) renders the board unacceptable.

Where defects are found in the basic board material, the methods given in **12.1** to **12.4** may be used. Typical defects are burns, blisters, splits, minor chips and delaminations.

12.1 Burns and Blisters — It is recommended that a burn or blister be repaired providing the burn or blister is not deeper than 50 percent of the board thickness and providing that the damage does not encroach on to any adjacent land area. Where a printed conductor runs over the area of damage, the printed conductor shall be cut for at least 5 mm each side of the cavity.

The method of repair is as follows:

a) Cut out the charred or burnt board material,

b) Apply epoxy resin to fill the cavity and allow to cure,

c) Trim any surplus resin and clean area of debris,

d) Where a printed conductor has been removed, one of the methods given in **7** may be used to replace the disconnection, and

e) Where an original coating has been removed it should be restored.

12.2 Splits and Fractures — Splits that run under printed conductors or lands and are more than 15 mm in length are not recommended as suitable subjects for repair. It is necessary to prevent a repairable split from running further. This can be achieved by drilling a 1 mm hole at the extreme end of the split.

The method of repair is as follows:

a) Clean the area thoroughly and force epoxy resin between the faces of the split. Penetration of the epoxy resin into the split can be improved by gently flexing the edge to be filled,

b) Clamp the two surfaces together and allow the resin to cure,

c) Trim any surplus resin and clean the area of debris, and

d) Where an original coating has been removed it should be restored.

12.3 Chips and Delaminations — These may include minor delaminations or breaking caused by mechanical impact. Chips and delaminations that run under printed conductors are not suitable subjects for repair.

a) *Minor chips*

1) Clean the edges to be repaired and make a mould or support for the epoxy resin filler,

2) Fill the mould with epoxy resin filler and ensure that any delamination is penetrated,

3) Allow the epoxy resin to cure and remove the mould, and

4) Trim to original shape the edges and both surfaces of the board.

b) *Minor delaminations*

1) Remove all loose material with a glass fibre brush,

2) Force an epoxy resin adhesive into the edges of delamination (damaged area),

3) Using a suitable clamp compress the delaminated area to its original shape,

NOTE — It is desirable to lightly coat the clamp faces with a releasing agent to prevent clamp adhesion to the printed wiring board surface.

4) Allow the epoxy resin to cure, and
5) After removing the clamps clean the edges of the printed wiring board to restore the original printed wiring board contour.

13. INCLUSIONS

13.1 Removal of Inclusions — An inclusion is defined as any foreign body contained within the bare copper clad material or prepreg, or introduced between the bare material during processing. All inclusions should be considered electrically conductive.

13.1.1 An inclusion is detrimental when it either:

a) reduces the specified insulation gap between conductors; or
b) has any dimensions exceeding 0·75 mm.

Hair-like and non-conspicuous inclusions situated in a non-functional area are not detrimental and need not be removed.

13.1.2 Inclusions may be removed using the following method:

a) Using a viewer and air pencil fitted with a suitable dentist burr, remove inclusion and surrounding substrate material exercising great care, particularly if the inclusion lies across lands and/or conductors,
b) Remove all debris from the cavity and heat dry the printed wiring board,
c) Whilst still warm, fill the cavity with an approved resin and allow to cure,
d) When the resin has cured, trim away any surplus, and
e) Where an original coating has been removed, it should be restored.

14. SHORT OR NEAR SHORT CIRCUITS ON THE SURFACE OF THE LAMINATE

14.1 A short circuit is an electrical conductive path bridging together non-common external conductors on the surface of a circuit board.

A short circuit may be removed by either cutting away the offending conducting path using a scalpel or similar instrument.

14.1.1 After establishing discontinuity, the worked area may be coated with a varnish of resin which is compatible with existing or subsequent coating material.

15. REPAIR OF INNER LAYERS OF MULTILAYER PRINTED WIRING BOARDS

15.0 It is considered that repairs to inner layers of multilayer printed boards requires a very high degree of skill and the use of specialized equipment. Any such repair technique should therefore be a matter of negotiation with the customer and should be clearly defined.

Any proposed repair technique should not adversely affect the board design parameters and/or its electrical and mechanical properties.

15.1 Internal Short Circuit (Multilayer Board only) — An internal circuit is considered to be an electrical conductive path bridging to gether non-common conductors on the internal layer of multilayer printed wiring board.

The method of removal is as follows:

a) Using a viewer and high speed drill with a suitable dentists, burr, carefully remove substrate from around the defect and establish the nature of the defect.

b) Remove the defect taking great care not to damage adjacent lands or conductors. Remove all loose particles and place board in an oven for 15 min at 55 $\pm$ 5°C.

c) Remove board from oven and whilst still hot, fill the cavity with resin, and allow to cure.

d) After cooling, trim away surplus resin flush with the board surface.

e) Where an original coating has been removed it should be restored.

15.2 Open Circuit on Internal Conductors After Lamination (Multilayer Printed Wiring Boards only)

The method of repair is as follows:

a) The exact location of the open circuit should be identified before commencing.

b) Using a high speed drill and dentists, burr, remove substrate material from above the fault until the conductor is exposed for a distance of at least 1 mm either side of the break. It is important that the copper surface is electrically conductive, and all debris removed.

c) Carefully fill the cavity with conductive compound and air cure for 10 min, followed by oven curing.

d) After cooling, use the high speed drill and dentists, burr and re-machine the now filled aperture back below the substrate surface leaving cured compound in the break.

e) Electrically check the repair by:

1) passing a current of 3 A for approximately 60 seconds, and

2) applying a voltage to the conductor either side of the repair, without insulation breakdown.

f) Using a selective plating system and copper solution, locally plate the repair for the required thickness, wash reworked area in water and oven dry.

g) Finally, fill the aperture with resin after heating board for 15 min in the oven and cure. After cooling, trim resin flush with the surface.

h) Where an original surface coating has been removed, it should be restored.

16. REPAIRS TO PRINTED EDGE CONNECTORS

16.0 Repairs to printed edge connectors are not generally recommended. However, isolated recovery of high value printed boards with damaged printed edge contacts may be permitted, subject to the agreement of the customer, using methods described in this clause.

16.1 Defective Edge Contacts (Surface Damage Only) — Where damage to the gold plating only has occurred, it may be reworked in the following way:

a) Mask the board around the damaged area using plating masking tape.

b) Remove the gold plating from the contacts to be reworked using a carborundum stick, ensuring that no particles remain and that the under plate is undamaged.

c) Swab the area with degreasing solvent and then lightly clean using precipitated chalk and water. Finally, rinse in running water for 30 seconds.

d) Immerse the contact area in a solution to activate the contact's surface, and then place in cold running water for a maximum of 6 minutes before plating.

e) Using a selective plating system with a suitable gold solution, and whilst the board is still wet, quickly gold flash all exposed underplate and then plate each individual contact to the required thickness.

f) When complete, rinse in running water for 30 seconds, remove the masking tape and clean off adhesive residues with solvent.

g) Rinse the panel for a further 2 min and dry the panel using a hot air system.

NOTE 1 — This technique should not be used if the under plating or base copper is damaged, pitted or missing.

NOTE 2 — It is highly recommended that repairs which involve the use of plating apparatus are more appropriate to a plating laboratory.

16.2 Defective Edge Contacts — Same procedure shall be followed as for complete contact replacement as described in **16.3** below.

16.3 Complete Contact Replacement — Where a contact is damaged beyond the limit reworkable by the method given in **16.1** the only method of replacement is as follows:

a) Using a machine tool adapted for high speed cutting, with a dentists burr, machine away the defective contact for approximately half the depth of the substrate and remove at least 1 mm of the contact tail (*see* Fig. 25).

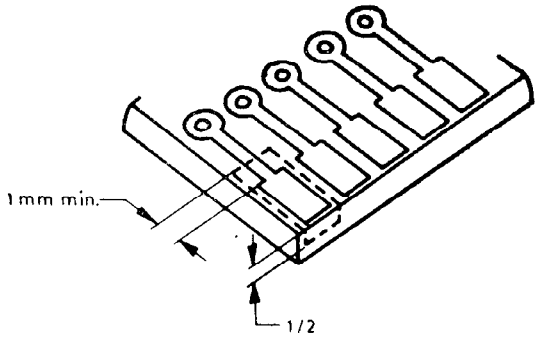


FIG. 25 PRINTED EDGE CONNECTOR — CONTACT REPLACEMENT METHOD

b) From a suitable scrap board, machine cut tab which dimensionally will just fit into the aperture machined into the defective board. Ensure that the contact surface will be flush with the rest of the contacts.

c) Bond the replacement tab into position using a suitable adhesive, and cure. It is essential to ensure that the contact surface is free from adhesive.

d) After curing, remake the electrical contact by selective a suitable method, detailed in **7**.

NOTE 1 — It is emphasized that this technique requires specialized equipment and a high degree of skill.

NOTE 2 — Printed wiring boards with edge connectors on both sides should not have directly opposite contacts replaced.

17. PROTECTIVE COATING REMOVAL

17.1 Where the boards requiring rework have a surface coating, this needs to be removed from the local rework area. Coating removal can be achieved using the following methods:

a) A suitable solvent can be used. Typical solvents (depending upon the coating material), are xylene trichloroethane, methylene chloride.

Care should be taken when using solvents to ensure that boards, components and the operator are adequately protected from the hazards associated with the use of these materials.

b) Abrasive removal can be achieved using either manual or miniature rotary powered methods.

Stiff nylon bristle or glass fibre brushes are commonly used, or impregnated rubber tools may prove suitable alternatives. Whichever system is chosen, thorough removal of debris is a prerequisite to the production of a satisfactory repair.

17.1.1 After completion of the repair the surface coating should be restored.

18. MODIFICATION OF ASSEMBLED PRINTED BOARDS

18.0 Modification to printed wiring boards usually involves the addition and/or removal of conductors and components. These are generally modifications to the design and should, therefore, be defined on an engineering drawing by the designer. To ensure that alternations and modifications conform to good practice it is recommended that the designer follows the recommendations and methods of this guide.

NOTE — Some techniques suggested are not suitable prior to mass soldering.

18.1 Permitted Number of Alterations Modifications Per Printed Wiring Board — Providing the number does not infringe any customer specification there need be no limit to the number per board.

Consideration should be given to the overall appearance when hand wired modifications are carried out.

Modifications/alterations to the printed edge connector in the vicinity of the gold plated plug area are not recommended.

18.2 Removal of Unwanted Components (*see* 6)

18.3 Removal of Unwanted Conductors

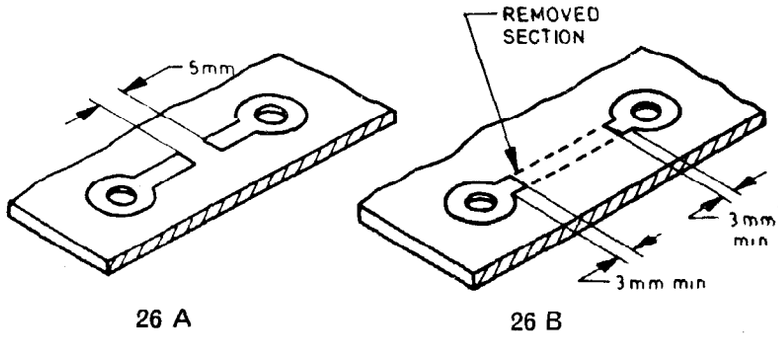


FIG. 26 REMOVAL OF UNWANTED CONDUCTORS

18.3.1 The circuit may be broken by cutting with a scalpel or similar instrument removing approximately 5 mm from the conductor at the mid or any convenient point and the cut ends sealed with an epoxy adhesive.

18.3.2 Where there is a need for the printed pattern to simulate the conductor pattern of the modified artwork, the conductor may be removed to the nearest remaining lands. (*see* dimensions in Fig. 26). The ends of the conductor should then be sealed with an expoxy adhesive.

Removal of conductors should only be made where there is a design requirement to simulate the new artwork pattern.

18.4 Fitting of Additional Components and/or Wires

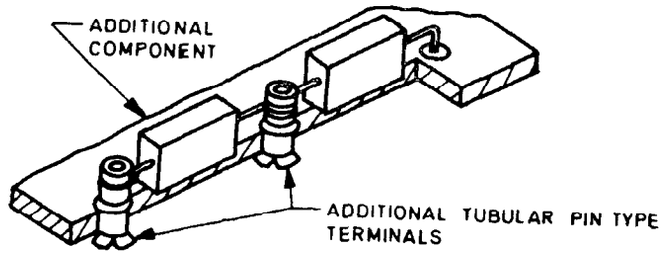


FIG. 27 FITTING OF ADDITIONAL COMPONENTS AND/OR WIRES

18.4.1 This method covers the addition of two or three lead components of the resistor capacitor, diode type and transistors (*see* Fig. 27).

18.4.2 Where there are vacant lands in the correct circuit position that have holes that will accommodate the additional component/wire without the need to enlarge the hole, the component/wire may be assembled in the normal way.

18.4.3 Multi-lead components such as integrated circuits. Dual-in-line packages etc should be added by a socket mounted to a sub-board than hand wired provided they do not exceed the condition of **18.1.**

18.5 The Addition of Connections to the Circuit Using Parallel Gap Welding Techniques — The additions to the circuit may be achieved using parallel welding techniques. The principles applied will be similar to the requirements of repairs using parallel gap welding (*see* **7**).

18.6 Modifications to Printed Edge Connectors — Modification of the printed edge connector fingers should not be permitted. Modifications to outgoing connections may however be achieved by attaching additional conductors to the appropriate printed wiring pattern elsewhere in the circuit (*see* Fig. 28).

Care must be taken to ensure that pins do not form an undesirable connection between two sides of a printed board.

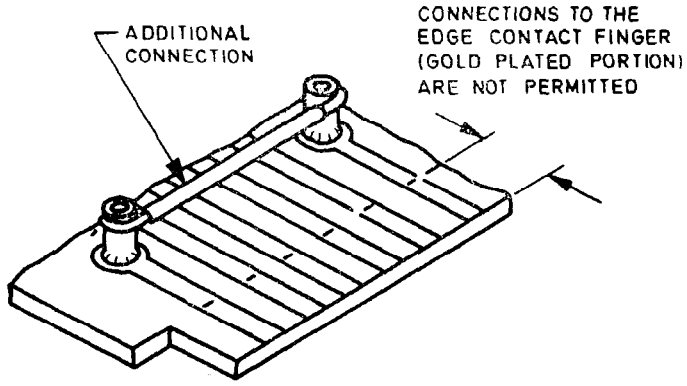


FIG. 28 MODIFICATION TO PRINTED EDGE CONNECTORS

19. GUIDE TO SUITABLE TOOLS AND MATERIALS

19.1 The following list is a guide to suitable tools and materials which are recommended for use in the repair methods specified in this guide:

a) Soldering irons of the low voltage, low wattage and temperature controlled to approximately 280°C with suitable soldering bits are considered necessary.

b) Desoldering tools with power operated, vacuum pumps when desoldering plated through holes or removing multi leg components of the dual-in-line circuit type.

Hand loaded desoldering tools may be suitable for a single hole desoldering.

c) Solder flux cored.

d) Two part epoxy adhesive.

e) Small hand tools. Tweezers, side cutters, scalpels, dental probes, spatulas, glass fibre or nylon bristle scratch brush, dental burrs, fine abrasive paper, carborundum sticks, small clamps, etc.

f) Tinned copper wire. Various diameters equivalent to original conductor current carrying capacitor.

g) Insulated tinned copper wire. Various diameters equivalent to the original conductor current carrying capacitor.

h) High speed hand held air drill with a range of suitable burrs and drills.

j) High speed drilling machine with suitable drills burrs and three axis controlled table movement for the repair of multilayer boards.

k) Cleaning fluid.

m) Polyurethene lacquer (varnish).

n) Weldable nichel tape — parallel gap welding.

p) Parallel gap welding machine with a range of electrodes.

q) Temperature controlled oven. Multilayer repairs.

r) Constant power supply cable of 3 A output. Multilayer repairs.

s) Eyelet insertion machine and eyelets.

t) Terminal insertion tool and terminals.

u) Optical viewer × 10 magnification.

v) Repair foils range of shapes and sizes for the reapair of lands and conductors.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2